REVIEW

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CLINICAL ENDOSCOPY

# Endoscopic management of postoperative bleeding

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Postoperative gastrointestinal bleeding is a rare but serious complication that can lead to prolonged hospitalization and significant morbidity and mortality. It can be managed by reoperation, endoscopy, or radiological intervention. Although reoperation carries risks, particularly in critically ill postoperative patients, minimally invasive interventions, such as endoscopy or radiological intervention, confer advantages. Endoscopy allows localization of the bleeding focus and hemostatic management at the same time. Although there have been concerns regarding the potential risk of creating an anastomotic disruption or perforation during early postoperative endoscopy, endoscopic management has become more popular over time. However, there is currently no consensus on the best endoscopic management for postoperative gastrointestinal bleeding because most practices are based on retrospective case series. Furthermore, there is a wide range of individual complexities in anatomical and clinical settings after surgery. This review focused on the safety and effectiveness of endoscopic management in various surgical settings.

**Keywords:** Endoscopy; Gastrointestinal hemorrhage; Postoperative hemorrhage

## INTRODUCTION

Endoscopy is the primary modality for managing gastrointestinal (GI) bleeding. It can be useful for various causes of upper and lower GI bleeding. Postoperative GI bleeding (PGIB) is a rare complication that is often self-limiting and is thus managed conservatively. Nevertheless, it should still be monitored because of the possibility and potential consequences of uncontrolled postoperative hemorrhage. PGIB is associated with prolonged hospital stay and increased morbidity and mortality, particularly in critically ill patients.[1-3] Severe postoperative hemorrhage can also lead to a poor overall five-year survival rate in patients with gastric cancer.[4]

Conservative management with blood transfusion, angiographic embolization, endoscopic intervention, and surgery are the therapeutic options for PGIB. Although reoperation is considered the mainstay of treatment for postoperative bleeding, it has been reported that patients who have undergone reoperation have more postoperative complications and a higher mortality rate.[5-7] In addition to massive bleeding, injuries from prolonged hemostatic procedures, accompanied by hypothermia, coagulopathy, and acidosis, can result in death.[4] Given the high morbidity and mortality associated with reoperation, minimally invasive procedures, such as angiographic interventions and endoscopic treatment, may be preferred for the diagnosis and treatment of PGIB, as an alternative to reoperation.[4,8] Endoscopic management can be used as a first-line treatment for postoperative intraluminal bleeding. While there is limited concrete evidence regarding complications from endoscopic management, accumulating evidence supports the efficacy and safety of this procedure, even in the early postoperative period.

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## CLINICAL PRESENTATION AND SOURCE OF PGIB

The clinical presentation of postoperative bleeding ranges from an asymptomatic decrease in hemoglobin level to overt signs of hemorrhage and hemodynamic instability. Hematemesis is a common symptom after GI surgery, which may be related to a small gastric pouch with limited gastric reservoir after surgery.[9] Hematochezia is the main manifestation of GI bleeding after colorectal surgery.[10] The source of bleeding can be intraluminal or extraluminal. A significant proportion of hemorrhage is extraluminal. Additionally, combined intraluminal and extraluminal bleeding is also common.[11] Intraluminal GI bleeding can be caused by a ruptured pseudoaneurysm secondary to an anastomotic leak after pancreaticoduodenectomy.[12]

The suture line is a major cause of intraluminal GI bleeding. In addition, stress-related mucosal damage can cause upper GI bleeding (UGIB), and conditions such as gastritis, duodenitis, gastric and duodenal ulcers, can be caused by colorectal or non-GI surgeries, such as cardiothoracic or vascular surgery. A Mallory-Weiss tear may occur as a result of postoperative nausea and vomiting.[13] Marginal ulcers related to delayed postoperative bleeding may develop from mucosal ischemia caused by perfusion defects, anastomotic tension, or the suture material.[14] The bleeding focus can be a pouch, a contiguous small intestine, an excluded limb including the stomach, duodenum, and bypassed small intestine, or damaged vascular structure resulting in intra and extraluminal bleeding.[15] Common hepatic artery and its branches, splenic artery, peripancreatic artery, and other abdominal arteries are reported as a focus of postoperative bleeding.[4,16]

## EPIDEMIOLOGY

The incidence of PGIB varied according to the type of surgery performed (Table 1).[8-11,16-26] Major GI surgery is associated with a relatively high incidence of PGIB. In a population-based study conducted in Korea, the incidence rate of PGIB was 1.92% after conducting a major GI surgery.[2] In particular, pancreatic surgery has a relatively high incidence of PGIB and mortality rates compared to other types of GI surgery.[17] In addition, PGIB can result from non-GI surgery. Patients undergoing major cardiovascular (1.89%), head and neck (0.71%), genitourinary (0.54%), or orthopedic (0.45%) surgeries also develop PGIB.[2]

After gastrectomy, PGIB can occur in less than 3% of patients who have undergo surgery.[1] The reported incidence of PGIB after bariatric surgery is between 0.5% and 5.8%,[18,27] and the overall mortality rate is <1%.[28] In a retrospective study on laparoscopic Roux-en-Y gastric bypass (RYGB), postoperative bleeding occurred in 1.5% (652/43,280) of patients. PGIB was related to a longer hospital stay (four vs. two days) and a higher mortality rate (1.38% vs. 0.15%). In addition, 25.3% of the patients underwent reoperation, and 14.9% underwent endoscopy for GI bleeding.[1]

Postpancreatectomy hemorrhage, which occurs after pancreatic surgery, has an incidence that range from 3% to 16% (weighted mean: 5%). Moreover, it is responsible for 21% of mortality.[29] In cases of colorectal surgery, 0.3% to 6.5% of patients experienced PGIB.[19,30] Notably, UGIB can occur in colorectal surgery. In a retrospective study including 2,514,228 patients who underwent colorectal resection, 0.5% developed postoperative UGIB, which was related to a higher mortality rate compared to non-bleeding patients (odds ratio [OR], 3.57; 95% confidence interval [CI], 3.40–3.75; $p$<0.01).[3]

## RISK FACTORS FOR PGIB

Several factors affect the risk of PGIB development. Increased age and comorbidities have been associated with an increased risk of postoperative bleeding.[2,13] In a single center study involving 5,739 patients who underwent gastrectomy for gastric cancer, male sex (hazard ratio [HR], 2.25; 95% CI, 1.08–4.70), comorbidity (HR, 2.71; 95% CI, 1.44–5.10), and previous abdominal surgery (HR, 2.79; 95% CI, 1.32–5.87) were associated with an increased risk of PGIB.[20] Wang et al.[31] reported that the incidence of postoperative complications increased as the number of complications increased following gastrectomy (r=0.090, $p$=0.014). Diabetes mellitus (adjusted OR [aOR], 1.34; 95% CI, 1.24–1.45), hypertension (aOR, 1.31; 95% CI 1.20–1.42), chronic liver disease (aOR, 1.54; 95% CI, 1.38–1.73), congestive heart failure (aOR, 1.78; 95% CI, 1.60–1.98), and peptic ulcer disease (aOR, 1.20; 95% CI, 1.11–1.30) were also associated with an increased risk of PGIB in a population-based study conducted in Korea. However, non-steroidal anti-inflammatory drug (NSAID) use was not associated with an increased risk of PGIB.[2] A recent meta-analysis revealed that the use of NSAIDs in the perioperative period did not increase the risk of postoperative bleeding complications.[32] In addition, preoperative administration of anticoagulants was reported to be a risk factor for PGIB after RYGB.[1,33] Moreover, preoperative antiplatelet/anticoagulation therapy was reported as a risk factor for bleeding

**Table 1.** Characteristics of postoperative bleeding

| Study | Surgery (*n*) | Source of bleeding | Incidence (%) | Risk factors of bleeding | Treatment (%) |
|---|---|---|---|---|---|
| Tanizawa et al. (2010)[25] | Gastrectomy (1,400) | Gastroduodenostomy, gastrojejunostomy, staple line of stomach, esophagojejunostomy | 0.43 | Lymph node dissection (≤D1) | Endoscopy (83), surgery (17) |
| Jeong et al. (2011)[24] | Gastrectomy (1,027) | Anastomosis, pseudo-aneurysm | 1.6 | Operating time ≥3 hr, BMI ≥26 kg/m$^2$ | Endoscopy (12), surgery (19), conservative (69) |
| Kim et al. (2012)[8] | Gastrectomy (2,031) | Gastrojejunostomy, gastroduodenostomy, esophagojejunostomy | 0.3 | Billroth II anastomosis, manual-anastomosis | Endoscopy (85), conservative (14) |
| Park et al. (2014)[20] | Gastrectomy (5,739) | Anastomosis | 0.8 | Male, comorbidity, previous abdominal surgery, palliative surgery | Endoscopy (28), surgery (28), conservative (44) |
| Lee et al. (2017)[23] | Gastrectomy (16,591) | Anastomosis | 0.22 | Subtotal gastrectomy | Endoscopy (69), surgery (17), conservative (14) |
| Fernández-Esparrach et al. (2008)[18] | RYGB (381) | Anastomosis | 5.8 | | Endoscopy (27), conservative (73) |
| Jamil et al. (2008)[9] | RYGB (933) | Gastrojejunostomy | 3.2 | | Endoscopy (80), conservative (20) |
| Rabl et al. (2011)[16] | RYGB (742) | Gastrojejunostomy, gastric remnant staple line | 3.5 | Diabetes mellitus | Endoscopy (75) |
| Golda et al. (2013)[21] | Right colectomy (350) | Anastomosis | 4.9 | | Endoscopy (18) |
| Fernández de Sevilla Gómez et al. (2014)[10] | Colectomy, ileal resection (2,069) | Anastomosis | 3.17 | | Endoscopy (5), surgery (14), angiography (14), conservative (61) |
| Lou et al. (2014)[19] | Anterior resection (2,181) | Anastomosis | 0.3 | | Endoscopy (100) |
| Besson et al. (2016)[22] | Left colectomy (729) | Anastomosis | 6.4 | Stapled anastomosis, diverticular disease | Endoscopy (79) |
| Yekebas et al. (2007)[26] | Pancreaticoduodenectomy (1,669) | Gastrojejunostomy, enteroenteric anastomosis | 2.2 | Pancreatic fistula | Endoscopy (42) |
| Feng et al. (2014)[11] | Pancreaticoduodenectomy (840) | Gastrojejunostomy, marginal ulcer, cholangiojejunostomy, pancreaticojejunostomy | 3.3 | Male, end-to-side-pancreaticojejunostomy, small pancreatic duct | Endoscopy (60) |
| Gao et al. (2021)[17] | Biliary-pancreatic surgery (37,772) | Gastric stump, anastomosis, Dieulafoy lesion | 0.069 | | Endoscopy (100) |

BMI, body mass index; RYGB, Roux-en-Y gastric bypass.

after esophagectomy.[34]

Surgery type was also associated with the risk of developing PGIB. Palliative setting operations have been associated with a higher risk of PGIB in patients undergoing gastric cancer surgery (HR, 4.14; 95% CI, 1.44–11.89).[20] Particularly in colorectal surgery, cancer surgery (OR, 1.59; 95% CI, 1.47–1.71; $p$<0.01), total colectomy (OR, 4.19; CI 3.07–5.72), and transverse colectomy (OR, 3.30; 95% CI, 2.49–4.37) have been identified as factors that result in higher rates of postoperative UGIB.[3] In addition, a lower tumor location in the rectum is an independent risk factor for postoperative anastomotic bleeding (risk ratio, 4.78; $p$=0.041) in patients undergoing lower anterior resection.[30] End-to-side ileocolic anastomosis is related to anastomotic bleeding compared to other techniques of ileocolic anastomosis.[21] However, surgical reconstruction methods do not seem to have a clinical impact on patients undergoing pancreatoduodenectomy.[35] Regarding suture technique, there was no statistically significant difference in the rate of bleeding between hand-suture and stapling techniques in a recent meta-analysis of 26 studies.[36]

## POSTOPERATIVE ENDOSCOPY

Endoscopy for PGIB enables locating the bleeding focus and providing hemostasis simultaneously. Moreover, endoscopy can be done to estimate the risk of rebleeding.[37,38] Moreover, it has been associated with less costs and hospital stays caused by reoperation.[30] However, there are concerns about the complications induced by endoscopy in the early postoperative period. Indeed, the anastomosis starts to weaken in the first two postoperative days and approaches maximal strength at approximately four weeks after anastomotic creation. During this period, the submucosal layer provides most of the strength of the anastomosis[39,40]; hence, the anastomosis is fragile during this period. There is concern that air insufflation, local endoscope trauma, and torque during endoscopic procedures can increase mechanical tension on the anastomosis, thereby resulting in anastomotic leakage or perforation.[30,41,42] However, it has been suggested that early postoperative endoscopy is generally safe. Park et al.[43] reported that intraoperative endoscopy performed immediately after surgery was safe, with no complications related to endoscopy. Another study found that endoscopy, performed within 30 days of the index operation (median [interquartile range], 22 [16–26] days) resulted in no complications related to endoscopy, such as anastomotic perforation or disruptions, after RYGB.[44]

## ENDOSCOPIC MANAGEMENT

In many cases, conservative management is sufficient for treating GI bleeding. However, in patients with uncontrolled postoperative bleeding, therapeutic interventions should be considered to reduce morbidity and mortality.[27,45] Endoscopic management is safe and is more advantageous over the surgical approach in terms of cost savings and reduced length of hospital stay. Moreover, repeat endoscopy can be done as a secondary intervention because of its minimally invasive nature, efficacy, and non-requirement of general anesthesia.[46]

The hemostatic devices and techniques used for postoperative bleeding did not differ from those used for nonoperative GI bleeding. The options include hemoclipping, epinephrine injection, hemospray, electrocoagulation, and argon plasma coagulation. In general, epinephrine injection monotherapy is considered less effective than combined therapy with epinephrine injection and mechanical hemostasis.[47] However, there are complexities to consider in patients with postoperative bleeding due to anatomical changes after surgery and comorbid patient status. The success of endoscopic management was closely related to the type of surgery performed (Table 2).[8,9,12,16-19,21-23,25,26,42] Assessment and identification of the bleeding location can be more difficult in patients who have undergone pancreaticoduodenectomy than in those who have undergone gastrectomy or colectomy.[8,11,22] After gastrectomy, the small remaining stomach volume may limit the space for endoscopic manipulation, and endoscopy may fail to reach the anastomotic site because of blood clots obstructing the intestinal lumen or the length of the bypassed limb.[20,23,48]

Hemoclips are efficacious and durable for anastomotic bleeding, anastomotic leaks, and perforations. It can result in minimal tissue injury.[49] However, anatomical changes after surgery can make the application of hemoclips technically more difficult. The exact facing of the lesion and deployment of the hemoclip to the bleeding site can be problematic in some cases. In addition, the technical success of endoscopic management can be affected by the location of the bleeding at the anastomotic ring. In a recent study, hemostasis on the posterior wall side of the anastomotic ring was associated with the lowest hemostasis success rate compared with lesions on the anterior wall side (50% vs. 100%, respectively).[23] Moreover, despite the superiority of combined hemostatic modalities for bleeding control,[50] it may not be possible to use it for postoperative bleeding. Injection monotherapy has been used to control bleeding with acceptable success rate.[8,18,51] In addition, irrigation with an epinephrine solution can be used to control a small amount of bleeding.[30] However, epinephrine injection monotherapy can possibly be associated with rebleeding, especially in the presence of arterial spurting. Thermal therapy at the staple line and anastomosis site requires caution because of the risk of tissue injury, which can lead to perforation.[52]

Although there is insufficient evidence, an over-the-scope clip (OTSC) can be used to control postoperative bleeding. OTSC provide a higher compression pressure and can capture a large volume of tissue. OTSC treatment is superior to standard therapy in recurrent peptic ulcer bleeding.[53] In addition to this, in a recent randomized controlled trial, the initial OTSC treatment was efficacious in patients with severe UGIB as pri-

**Table 2.** Endoscopic treatment of postoperative bleeding according to the type of surgery

| Study | Type of surgery | Time to bleeding | Endoscopic management (%) | Success (%) | Risk factor of failure | Adverse events |
|---|---|---|---|---|---|---|
| Tanizawa et al. (2010)[25] | Gastrectomy | 4.8 hr | Hemoclip (100) | 100 | | Abscess |
| Kim et al. (2012)[8] | Gastrectomy | 2.9 (1–4) day | Hemoclip (14), epinephrine injection (71) | 100 | | |
| Lee et al. (2017)[23] | Gastrectomy | 45 (21.5-126) hr | Hemoclip (52), epinephrine injection (32), fibrin glue injection (24), coagrasper (4), combination (24) | 64 | Large amount of blood, noncooperation, posterior wall side location | No |
| Fernández-Esparrach et al. (2008)[18] | RYGB | 6 (6–10.5) hr | Epinephrine (17), epinephrine plus polidocanol (83) | 100 | | No |
| Jamil et al. (2008)[9] | RYGB | 6.5 (0–43) hr | Epinephrine (11), heater probe (15), epinephrine+heater probe (52), hemoclip (7) | 78 | | Aspiration, perforation |
| Rabl et al. (2011)[16] | RYGB | Early (≤24 hr), 73.7%; late (2–14 day), 26.3% | Epinephrine injection (60), clipping (40) | 100 | Bypassed gastric remnant | No |
| Golda et al. (2013)[21] | Right colectomy | 6.5 (2.8–9.3) day | Epinephrine injection (33), epinephrine/etoxysclerol (67) | 33 | Blood and fecal contamination | Ileus |
| Lou et al. (2014)[19] | Anterior resection | 1 (1–3.3) day | Electrocoagulation (50), hemoclip (50) | 100 | | No |
| Besson et al. (2016)[22] | Left colectomy | 2 day | Hemoclip (27), sclerosis (30), hemoclip+sclerosis (19) | 100 | | No |
| Martínez-Serrano et al. (2009)[42] | Colorectal resection | 6.5 hr (0.5 hr–9 day) | Anastomosis washout (100) | 85.7 | | No |
| Yekebas et al. (2007)[26] | Pancreaticoduodenectomy | 4 (2–8) day | | 20 | Beyond endoscopic accessibility, late bleeding | |
| Chen et al. (2015)[12] | Pancreaticoduodenectomy | 5 (5–22) day | | 57.1 | | |
| Gao et al. (2021)[17] | Biliary-pancreatic surgery | 8.1±5.7 day | Clipping (73), sclerosing agent injection (4), epinephrine injection (12), sclerosing plus clipping (8), epinephrine plus clipping (4) | 73.1 | Bleeding to endoscopy time (>12 hr) | No |

Values are presented as median (interquartile range), median (range), or mean±standard deviation.
RYGB, Roux-en-Y gastric bypass.

mary therapy.[54] In a case report, it was reported that OTSC was successfully applied to the gastroduodenal anastomotic bleeding three weeks after the creation of Billroth I anastomosis.[55] Moreover, hemospray can be a useful option for hemostasis of postoperative bleeding. Hemospray provides hemostasis by sealing injured blood vessels and by activating platelets and the intrinsic coagulation pathway.[56] In a randomized controlled trial, hemospray had a similar efficacy as that of combination therapy of hemoclip and epinephrine.[57] In addition, hemospray was effective in achieving immediate hemostasis in GI bleeding in a recent meta-analysis. The overall pooled clinical success rate after the application of hemospray was 92%.[58] Moreover, hemospray can be used as a primary or combination therapy. The potential advantage of hemospray over other modalities is that it can be used for obscured bleeding sites[59] or in lesions that are difficult to conduct an en face therapeutic positioning due to angulations or narrow lumens, such as gastrojejunostomy or duodenoduodenal anastomosis.[60] However, overall pooled early rebleeding rates after application of hemospray is quite high.[58] Another novel modality for hemostasis is endoscopic suturing. In one case report, a massive hemorrhage due to a marginal ulcer 10 days after RYGB was successfully managed with endoscopic sutures without any complications.[61]

## PROTON PUMP INHIBITORS AND ANGIOGRAPHY

The administration of proton pump inhibitor (PPI) is recommended as an adjuvant to endoscopic hemostasis in the management of UGIB.[62] When the bleeding site is located in the gastric pouch or gastroenteric anastomosis, endoscopic treatment, combined with intravenous PPIs, should be considered. Although it is not recommended to use pre-endoscopic PPIs, they reduce the risk of stress-induced GI bleeding in critically ill patients.[63] Additionally, a recent systematic review and meta-analysis revealed the benefit of prophylactic administration of PPIs in reducing marginal ulceration after gastric bypass surgery (OR, 0.5; 95% CI, 0.28–0.90; $p$=0.02).[64]

Angiography can be used to identify the source of bleeding. Additionally, it can be used for the provision of therapeutic intervention. Angiography is the preferred method for both the diagnosis and treatment of patients with suspected pseudoaneurysm bleeding. Angiographic intervention may be considered in cases of endoscopic treatment failure or recurrent bleeding.[65] Furthermore, a recent systematic review reported the superiority of interventional radiology over laparotomy in terms of mortality (22% vs. 47%, $p$=0.02) with no statistically significant difference in achieving hemostasis (76% vs. 80%, $p$=0.35). However, surgery is a viable treatment option in situations where interventional radiology is unavailable and in patients who cannot be resuscitated.[66]

## ENDOSCOPIC MANAGEMENT ACCORDING TO THE TYPE OF SURGERY

### Esophageal surgery

Evidence regarding early postoperative endoscopy after esophageal surgery is limited, particularly in patients with postoperative bleeding. However, Nishikawa et al.[67] reported that endoscopy performed within two weeks after surgery was safe and useful for detecting anastomotic complications, such as stricture or leakage. In addition, the maximal internal pressure during endoscopy did not exceed the physiologic pressure. Okada et al.[68] reported that a pressure gradient of 1 to 9 cm $H_2O$ was created in the internal conduit during endoscopy on the day after esophagectomy. The maximal internal pressure was 29 cm $H_2O$, which is below the physiological pressure caused by swallowing and vermiculation. Accordingly, endoscopy is supposed to be safe and useful even in the early postoperative period.

### Gastric cancer surgery

In the Korean nationwide survey, the total volume of stomach surgery is still high despite the increasing incidence of early gastric cancer.[69] After distal gastrectomy, the most commonly used anastomotic method was the Billroth II (45.0%), followed by Billroth I (33.6%) and Roux-en-Y reconstruction (20.5%).[69] After proximal gastrectomy, the most common reconstruction method was double tract reconstruction (81.3%). In patients who underwent a totally laparoscopic distal gastrectomy, Billroth II (51.4%) reconstruction using a linear stapler was frequently used.[69] The incidence of postoperative bleeding was more frequent after subtotal gastrectomy (61.5%) than after total gastrectomy (38.5%).[24] PGIB can arise from the anastomosis, staple line, and arterial pseudoaneurysm.[24,25] In hemodynamically stable patients, conservative management is expected to be sufficient. In a multicenter study involving 1,485 patients who underwent laparoscopy-assisted gastrectomy, 75% of intraluminal bleeding was controlled by conservative management.[70] In most studies, the success rate of endoscopic treatment was quite high after gastrectomy. However, when massive hemorrhage occupies the remnant lumen, the endoscopist may fail to detect the bleeding focus.[20,23] In cases of arterial bleeding, sudden onset of hemodynamic instability, abdominal distension, and drainage of fresh blood can be observed, and arterial embolization or surgery should be considered to manage the bleeding. In addition, arterial pseudoaneurysmal bleeding can result in luminal bleeding with massive hematemesis or hematochezia and can thus limit its ability to detect the bleeding focus.[20,24]

### Bariatric surgery

Globally, the burden of bariatric surgery is increasing due to the increasing prevalence of obesity. Among bariatric surgeries, sleeve gastrectomy is the most common procedure (45.9%), followed by RYGB (39.6%).[71] After bariatric surgeries, PGIB can arise from anastomoses, staple lines, the pouch, the contiguous small intestine, the excluded stomach, or the bypassed small intestine.[72] Early bleeding, defined as bleeding within 30 days after surgery, usually occurs at the gastrojejunal anastomosis. Delayed bleeding, defined as bleeding after 30 days, usually occurs secondary to an anastomotic ulcer.[73] In patients who have undergone Roux-en-Y reconstruction, the diagnosis of postoperative bleeding can be difficult when the source of the bleeding is in the bypassed gastric remnant, proximal duodenum, or biliopancreatic limb. In such cases, double-balloon enteroscopy or pediatric colonoscopy could be useful in identifying the bleeding foci.[15,74,75] In the literature, anastomotic bleeding has been successfully controlled with epinephrine/polidocanol injection, heater probe, and hemoclipping.[9,16,18] However, 17% rebleeding after initial endoscopic management has been reported in patients receiving epinephrine and heater probe therapy.[9]

### Pancreaticoduodenectomy

Pancreaticoduodenectomy is a complex and high-risk surgery involving gastrojejunostomy, hepaticojejunostomy, and pancreaticojejunostomy. Pylorus-preserving pancreaticoduodenectomy, as the name suggests, involves the preservation of the stomach, pylorus, and proximal duodenum. These structures are then anastomosed to the jejunum.[76] The success rate of endoscopic treatment after pancreaticoduodenectomy is relatively low compared with those of other GI surgeries. In a systematic review and meta-analysis, the overall success rate of endoscopic treatment was 48%, while the mortality rate was lower after angiographic or endoscopic intervention than after reoperation (15%, 24%, and 37%, respectively). The most common bleeding focus was the gastroduodenal artery stump (29%), followed by the common hepatic artery (19%), and the splenic artery (12%).[21] It is reported that the bleeding site can only be identified by endoscopy in 20% of patients.[26] Difficult accessibility to the pancreaticojejunostomy suture line or obscured visual field by active bleeding could possibly explain this.[77] Recently, Gao et al.[17] reported early endoscopic hemostasis performed for ≤12 hours was successful in 73.1% (19/26) patients who underwent biliary-pancreatic surgery. In this study, hemoclip was the most commonly used hemostatic modality (73%). Other hemostatic modalities include sclerosant injection, epinephrine injection, or combined injection and clipping. No endoscopic-procedure-related complications occurred.[17]

### Colorectal surgery

Postoperative bleeding after colorectal surgery is often mild and self-limiting. Most cases of bleeding arise from the anastomosis, causing intraluminal bleeding. Postoperative bleeding occurred early after surgery ranging from a median of 6.5 hours to 5.5 days.[19,42] In most cases, endoscopic treatment is effective. Lou et al.[19] reported that there were six out of the of 2,181 (0.3%) patients who had anastomotic bleeding after anterior resection. Anastomotic bleeding was controlled using electrocoagulation ($n$=4) or clipping ($n$=3). However, one patient experienced rebleeding after electrocoagulation. In addition, Besson et al.[22] reported 47 cases (6.4%) of postoperative bleeding in 729 patients who underwent left hemicolectomy. All cases of endoscopic treatment including hemoclip (27%), sclerosis (29.7%), and combination (18.9%) were successful among the patients who underwent endoscopy (78.7%). In another retrospective study involving 1,389 colorectal surgery, six out of seven patients were managed endoscopically with anastomotic washout (85.7%), while the remaining one patient failed to improve after hemostasis; hence, the patient was treated with re-anastomosis due to persistent bleeding and hemodynamic instability.[42] However, after right colectomy, it can be difficult for colonoscopy to reach the site of bleeding, particularly in the unprepared colon. Golda et al.[21] reported 17 cases (9.8%) of lower GI bleeding in patients who underwent right colectomy. Subsequently, colonoscopy was performed in three patients without complications. However, colonoscopy was not effective for hemostasis in one patient. Another patient was excluded due to blood and fecal contamination.

## CONCLUSIONS

PGIB rarely occurred. Nevertheless, if it does occur, it is associated with high morbidity and mortality rates. In patients with postoperative comorbidities, endoscopic intervention should be considered as a hemostatic strategy. Endoscopy enables localization of the bleeding focus and hemostasis. In addition, postoperative endoscopy is safe and efficacious in most cases, except for biliary-pancreatic surgeries. Hemoclipping is an effective and durable method for achieving hemostasis, even in the postoperative setting. However, the application of the endoscopic method and treatment efficacy are affected by the postoperative anatomy and bleeding location. Thus, endoscopists should know the type of surgery and time of onset to estimate the postulated bleeding focus. In cases where hemostasis is not achieved via endoscopic management, other treatment modalities, such as angiographic intervention or surgery, should be considered.

## Conflicts of Interest

The authors have no potential conflicts of interest.

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## Author Contributions

Conceptualization: KBB; Data curation: SHR; Supervision: KBB; Writing–original draft: SHR; Writing–review & editing: KBB.

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## REFERENCES

1. Zafar SN, Miller K, Felton J, et al. Postoperative bleeding after laparoscopic Roux en Y gastric bypass: predictors and consequences. Surg Endosc 2019;33:272–280.
2. Kim SH, Han K, Kang G, et al. Risk of postoperative gastrointestinal bleeding and its associated factors: a nationwide population-based study in Korea. J Pers Med 2021;11:1222.
3. Moghadamyeghaneh Z, Mills SD, Pigazzi A, et al. Risk factors of postoperative upper gastrointestinal bleeding following colorectal resections. J Gastrointest Surg 2014;18:1327–1333.
4. Yang J, Zhang XH, Huang YH, et al. Diagnosis and treatment of abdominal arterial bleeding after radical gastrectomy: a retrospective analysis of 1875 consecutive resections for gastric cancer. J Gastrointest Surg 2016;20:510–520.
5. Kassahun WT, Babel J, Mehdorn M. Assessing differences in surgical outcomes following emergency abdominal exploration for complications of elective surgery and high-risk primary emergencies. Sci Rep 2022;12:1349.
6. Lessing Y, Pencovich N, Nevo N, et al. Early reoperation following pancreaticoduodenectomy: impact on morbidity, mortality, and long-term survival. World J Surg Oncol 2019;17:26.
7. Enderes J, Pillny C, Standop J, et al. Operative re-intervention following pancreatoduodenectomy: what has changed over the last decades. J Clin Med 2022;11:7512.
8. Kim KH, Kim MC, Jung GJ, et al. Endoscopic treatment and risk factors of postoperative anastomotic bleeding after gastrectomy for gastric cancer. Int J Surg 2012;10:593–597.
9. Jamil LH, Krause KR, Chengelis DL, et al. Endoscopic management of early upper gastrointestinal hemorrhage following laparoscopic Roux-en-Y gastric bypass. Am J Gastroenterol 2008;103:86–91.
10. Fernández de Sevilla Gómez E, Vallribera Valls F, Espin Basany E, et al. Postoperative small bowel and colonic anastomotic bleeding: therapeutic management and complications. Cir Esp 2014;92:463–467.
11. Feng J, Chen YL, Dong JH, et al. Post-pancreaticoduodenectomy hemorrhage: risk factors, managements and outcomes. Hepatobiliary Pancreat Dis Int 2014;13:513–522.
12. Chen JF, Xu SF, Zhao W, et al. Diagnostic and therapeutic strategies to manage post-pancreaticoduodenectomy hemorrhage. World J Surg 2015;39:509–515.
13. Jones S, May AK. Postoperative gastrointestinal hemorrhage. Surg Clin North Am 2012;92:235–242.
14. Sapala JA, Wood MH, Sapala MA, et al. Marginal ulcer after gastric bypass: a prospective 3-year study of 173 patients. Obes Surg 1998;8:505–516.
15. Riquoir C, Díaz LA, Chiliquinga D, et al. Management of biliopancreatic limb bleeding after Roux-en-Y gastric bypass: a case report. Clin Endosc 2021;54:754–758.
16. Rabl C, Peeva S, Prado K, et al. Early and late abdominal bleeding after Roux-en-Y gastric bypass: sources and tailored therapeutic strategies. Obes Surg 2011;21:413–420.
17. Gao DJ, Wang SP, Fu XH, et al. Urgent endoscopy improves hemostasis in patients with upper gastrointestinal bleeding following biliary-pancreatic surgery: a retrospective analysis. Surg Laparosc Endosc Percutan Tech 2021;32:228–235.
18. Fernández-Esparrach G, Bordas JM, Pellisé M, et al. Endoscopic management of early GI hemorrhage after laparoscopic gastric bypass. Gastrointest Endosc 2008;67:552–555.
19. Lou Z, Zhang W, Yu E, et al. Colonoscopy is the first choice for early postoperative rectal anastomotic bleeding. World J Surg Oncol 2014;12:376.
20. Park JY, Kim YW, Eom BW, et al. Unique patterns and proper management of postgastrectomy bleeding in patients with gastric cancer. Surgery 2014;155:1023–1029.
21. Golda T, Zerpa C, Kreisler E, et al. Incidence and management of anastomotic bleeding after ileocolic anastomosis. Colorectal Dis 2013;15:1301–1308.
22. Besson R, Christidis C, Denet C, et al. Management of postoperative bleeding after laparoscopic left colectomy. Int J Colorectal Dis

2016;31:1431–1436.
23. Lee S, Ahn JY, Na S, et al. Clinical features of postoperative anastomotic bleeding after gastrectomy and efficacy of endoscopic hemostasis: a case-control study. Surg Endosc 2017;31:3210–3218.
24. Jeong O, Park YK, Ryu SY, et al. Predisposing factors and management of postoperative bleeding after radical gastrectomy for gastric carcinoma. Surg Today 2011;41:363–368.
25. Tanizawa Y, Bando E, Kawamura T, et al. Early postoperative anastomotic hemorrhage after gastrectomy for gastric cancer. Gastric Cancer 2010;13:50–57.
26. Yekebas EF, Wolfram L, Cataldegirmen G, et al. Postpancreatectomy hemorrhage: diagnosis and treatment: an analysis in 1669 consecutive pancreatic resections. Ann Surg 2007;246:269–280.
27. García-García ML, Martín-Lorenzo JG, Torralba-Martínez JA, et al. Emergency endoscopy for gastrointestinal bleeding after bariatric surgery: therapeutic algorithm. Cir Esp 2015;93:97–104.
28. Fecso AB, Samuel T, Elnahas A, et al. Clinical indicators of postoperative bleeding in bariatric surgery. Surg Laparosc Endosc Percutan Tech 2018;28:52–55.
29. Floortje van Oosten A, Smits FJ, van den Heuvel DA, et al. Diagnosis and management of postpancreatectomy hemorrhage: a systematic review and meta-analysis. HPB (Oxford) 2019;21:953–961.
30. Amr MA, Alzghari MJ, Polites SF, et al. Endoscopy in the early postoperative setting after primary gastrointestinal anastomosis. J Gastrointest Surg 2014;18:1911–1916.
31. Wang JB, Zheng CH, Li P, et al. Effect of comorbidities on postoperative complications in patients with gastric cancer after laparoscopy-assisted total gastrectomy: results from an 8-year experience at a large-scale single center. Surg Endosc 2017;31:2651–2660.
32. Bongiovanni T, Lancaster E, Ledesma Y, et al. Systematic review and meta-analysis of the association between non-steroidal anti-inflammatory drugs and operative bleeding in the perioperative period. J Am Coll Surg 2021;232:765–790.
33. Bakhos C, Alkhoury F, Kyriakides T, et al. Early postoperative hemorrhage after open and laparoscopic Roux-en-Y gastric bypass. Obes Surg 2009;19:153–157.
34. Aoyama T, Atsumi Y, Hara K, et al. Postoperative bleeding after esophagectomy for esophageal cancer in patients receiving antiplatelet and anticoagulation treatment. Anticancer Res 2020;40:2359–2364.
35. Schorn S, Demir IE, Vogel T, et al. Mortality and postoperative complications after different types of surgical reconstruction following pancreaticoduodenectomy-a systematic review with meta-analysis. Langenbecks Arch Surg 2019;404:141–157.
36. Steger J, Jell A, Ficht S, et al. Systematic review and meta-analysis on colorectal anastomotic techniques. Ther Clin Risk Manag 2022;18:523–539.
37. Mayer G, Lingenfelser T, Ell C. The role of endoscopy in early postoperative haemorrhage. Best Pract Res Clin Gastroenterol 2004;18:799–807.
38. Lim SG, Lee KM, Kim SS, et al. Endoscopic approach for postoperative complications following laparoscopic-assisted gastrectomy in early gastric cancer: literature review. Hepatogastroenterology 2012;59:1308–1312.
39. Thompson SK, Chang EY, Jobe BA. Clinical review: healing in gastrointestinal anastomoses, part I. Microsurgery 2006;26:131–136.
40. Morgan RB, Shogan BD. The science of anastomotic healing. Semin Colon Rectal Surg 2022;33:100879.
41. Nguyen NT, Rivers R, Wolfe BM. Early gastrointestinal hemorrhage after laparoscopic gastric bypass. Obes Surg 2003;13:62–65.
42. Martínez-Serrano MA, Parés D, Pera M, et al. Management of lower gastrointestinal bleeding after colorectal resection and stapled anastomosis. Tech Coloproctol 2009;13:49–53.
43. Park JH, Jeong SH, Lee YJ, et al. Safety and efficacy of post-anastomotic intraoperative endoscopy to avoid early anastomotic complications during gastrectomy for gastric cancer. Surg Endosc 2020;34:5312–5319.
44. Sharma G, Ardila-Gatas J, Boules M, et al. Upper gastrointestinal endoscopy is safe and feasible in the early postoperative period after Roux-en-Y gastric bypass. Surgery 2016;160:885–891.
45. Dick A, Byrne TK, Baker M, et al. Gastrointestinal bleeding after gastric bypass surgery: nuisance or catastrophe? Surg Obes Relat Dis 2010;6:643–647.
46. Malik AH, East JE, Buchanan GN, et al. Endoscopic haemostasis of staple-line haemorrhage following colorectal resection. Colorectal Dis 2008;10:616–618.
47. Shi K, Shen Z, Zhu G, et al. Systematic review with network meta-analysis: dual therapy for high-risk bleeding peptic ulcers. BMC Gastroenterol 2017;17:55.
48. Mala T, Søvik TT, Schou CF, et al. Blood clot obstruction of the jejunojejunostomy after laparoscopic gastric bypass. Surg Obes Relat Dis 2013;9:234–237.
49. Tang SJ, Rivas H, Tang L, et al. Endoscopic hemostasis using endoclip in early gastrointestinal hemorrhage after gastric bypass surgery. Obes Surg 2007;17:1261–1267.
50. Kim JS, Kim BW, Kim DH, et al. Guidelines for nonvariceal upper gastrointestinal bleeding. Gut Liver 2020;14:560–570.
51. Steffen R. Early gastrointestinal hemorrhage after laparoscopic gastric bypass. Obes Surg 2003;13:466.
52. Lee YC, Wang HP, Yang CS, et al. Endoscopic hemostasis of a bleed-

ing marginal ulcer: hemoclipping or dual therapy with epinephrine injection and heater probe thermocoagulation. J Gastroenterol Hepatol 2002;17:1220–1225.
53. Schmidt A, Gölder S, Goetz M, et al. Over-the-scope clips are more effective than standard endoscopic therapy for patients with recurrent bleeding of peptic ulcers. Gastroenterology 2018;155:674–686.
54. Jensen DM, Kovacs T, Ghassemi KA, et al. Randomized controlled trial of over-the-scope clip as initial treatment of severe nonvariceal upper gastrointestinal bleeding. Clin Gastroenterol Hepatol 2021;19:2315–2323.
55. Tontini GE, Naegel A, Albrecht H, et al. Successful over-the-scope clip (OTSC) treatment for severe bleeding due to anastomotic dehiscence. Endoscopy 2013;45 Suppl 2 UCTN:E343–E344.
56. Parsi MA, Jang S. Hemospray for diffuse anastomotic bleeding. Gastrointest Endosc 2014;80:1170.
57. Baracat FI, de Moura DTH, Brunaldi VO, et al. Randomized controlled trial of hemostatic powder versus endoscopic clipping for non-variceal upper gastrointestinal bleeding. Surg Endosc 2020;34:317–324.
58. Ofosu A, Ramai D, John F, et al. The efficacy and safety of hemospray for the management of gastrointestinal bleeding: a systematic review and meta-analysis. J Clin Gastroenterol 2021;55:e37–e45.
59. Granata A, Ligresti D, Curcio G, et al. Hemospray rescue treatment of gastroenteric anastomotic bleeding. Endoscopy 2015;47 Suppl 1 UCTN:E327–E328.
60. Gubler C, Metzler JM, Turina M. Hemospray treatment for bleeding intestinal anastomoses in the early postoperative period: a novel non-operative approach. Tech Coloproctol 2016;20:495–498.
61. Barola S, Magnuson T, Schweitzer M, et al. Endoscopic suturing for massively bleeding marginal ulcer 10 days post Roux-en-Y gastric bypass. Obes Surg 2017;27:1394–1396.
62. Laine L, Barkun AN, Saltzman JR, et al. ACG Clinical Guideline: upper gastrointestinal and ulcer bleeding. Am J Gastroenterol 2021;116:899–917.
63. Toews I, George AT, Peter JV, et al. Interventions for preventing upper gastrointestinal bleeding in people admitted to intensive care units. Cochrane Database Syst Rev 2018;6:CD008687.
64. Ying VW, Kim SH, Khan KJ, et al. Prophylactic PPI help reduce marginal ulcers after gastric bypass surgery: a systematic review and meta-analysis of cohort studies. Surg Endosc 2015;29:1018–1023.
65. Biondetti P, Fumarola EM, Ierardi AM, et al. Bleeding complications after pancreatic surgery: interventional radiology management. Gland Surg 2019;8:150–163.
66. Roulin D, Cerantola Y, Demartines N, et al. Systematic review of delayed postoperative hemorrhage after pancreatic resection. J Gastrointest Surg 2011;15:1055–1062.
67. Nishikawa K, Fujita T, Yuda M, et al. Early postoperative endoscopy for targeted management of patients at risks of anastomotic complications after esophagectomy. Surgery 2016;160:1294–1301.
68. Okada T, Kawada K, Nakajima Y, et al. Internal pressure of the conduit during endoscopy on the day after esophagectomy. Dig Surg 2013;30:183–189.
69. Information Committee of the Korean Gastric Cancer Association. Korean Gastric Cancer Association-led nationwide survey on surgically treated gastric cancers in 2019. J Gastric Cancer 2021;21:221–235.
70. Kim MC, Kim W, Kim HH, et al. Risk factors associated with complication following laparoscopy-assisted gastrectomy for gastric cancer: a large-scale Korean multicenter study. Ann Surg Oncol 2008;15:2692–2700.
71. Angrisani L, Santonicola A, Iovino P, et al. Bariatric surgery and endoluminal procedures: IFSO worldwide survey 2014. Obes Surg 2017;27:2279–2289.
72. Moreels TG, Hubens GJ, Ysebaert DK, et al. Diagnostic and therapeutic double-balloon enteroscopy after small bowel Roux-en-Y reconstructive surgery. Digestion 2009;80:141–147.
73. Souto-Rodríguez R, Alvarez-Sánchez MV. Endoluminal solutions to bariatric surgery complications: a review with a focus on technical aspects and results. World J Gastrointest Endosc 2017;9:105–126.
74. Tagaya N, Kasama K, Inamine S, et al. Evaluation of the excluded stomach by double-balloon endoscopy after laparoscopic Roux-en-Y gastric bypass. Obes Surg 2007;17:1165–1170.
75. Sakai P, Kuga R, Safatle-Ribeiro AV, et al. Is it feasible to reach the bypassed stomach after Roux-en-Y gastric bypass for morbid obesity?: the use of the double-balloon enteroscope. Endoscopy 2005;37:566–569.
76. McEvoy SH, Lavelle LP, Hoare SM, et al. Pancreaticoduodenectomy: expected post-operative anatomy and complications. Br J Radiol 2014;87:20140050.
77. Standop J, Schäfer N, Overhaus M, et al. Endoscopic management of anastomotic hemorrhage from pancreatogastrostomy. Surg Endosc 2009;23:2005–2010.